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2009 Annual Report of the Graduate School of Engineering and Management, Air Force Institute of Technology

Office of Research and Sponsored Programs, Graduate School of Engineering and Management, AFIT

Graduate School of Engineering and Management

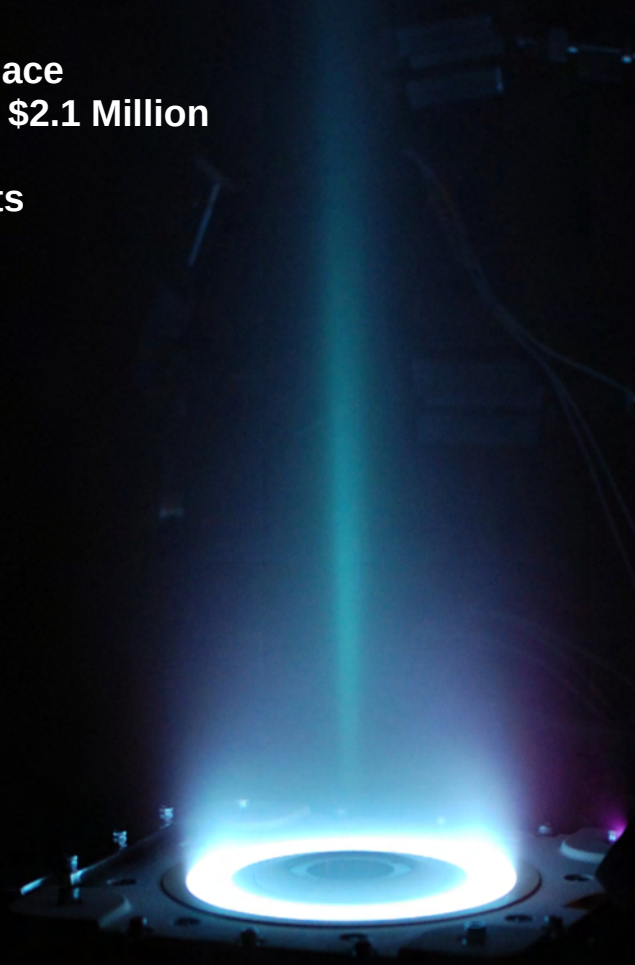
ANNUAL REPORT 2009

Air Force Institute of Technology

Department of Aeronautics & Astronautics

Center for Cyberspace
Research Awarded $2.1 Million

Research Highlights



AFIT 90th Anniversary Celebration

AFIT OVERVIEW

What started in 1919 as a school for select officers has grown into a premier educational institution for both officer and enlisted students, international students, Department of Defense civilians, and members of all branches of the armed services. AFIT accomplishes its mission through three resident schools—the Graduate School of Engineering and Management, the School of Systems and Logistics, and the Civil Engineer and Services School—as well as through its office of Civilian Institution Programs and the Center for Systems Engineering.

As the Air Force Institute of Technology continues its ninth decade of operation, faculty and staff members reflect with pride upon the contributions the Institute's graduates have made in engineering, science, technology, medicine, logistics and management. These immeasurable contributions have been vital to national security. The future promises to be even more challenging than the past, and AFIT is prepared to continue providing the environment and the opportunity for our students to develop the professional and technical skills needed to sustain the supremacy of America's air, space, and cyberspace forces.

MESSAGE FROM THE DEAN

Dr. Marlin U. Thomas, Dean

Each year I look forward to sharing our accomplishments with you in our AFIT Annual Report. AFIT now boasts over 18,000 graduates—men and women in leadership roles working to improve the lives of people throughout the world. Our mission to support our country's defense agencies remains strong as we continue to pursue our vision of being the top-ranked graduate school of choice in engineering and applied science for defense-focused, research-based education.

AFIT's six academic departments now offer twelve PhD programs and twenty-four master's programs, with our engineering programs accredited by the Accreditation Board for Engineering and Technology (ABET). We continue to expand our demand-driven Graduate Certificate Programs for individuals seeking advanced-level education in selected specialty areas beyond the bachelor's level. We provide distance learning for every major Air Force base in the U.S., the Naval Postgraduate School, and to bases in Hawaii and Japan.

Through joint collaboration and research, AFIT enjoys ongoing relationships with the Air Force Research Lab (AFRL), the High Energy Laser Joint Technology Office, the Joint Improvised Explosive Device Defeat Organization, the National Security Agency, the Air Combat Command and others. Additionally, we are exploring new or expanded relationships with the Air Force Nuclear Weapons and Counter-proliferation Agency, Defense Threat Reduction Agency, NSA's Tactical SIGINT Technology Division and the West Virginia High Technology Consortium. We continue to increase our funding through sponsored support and this year received one of our largest grants to date—$2.1 million—to continue our work with the National Science Foundation's Scholarship for Service Program Initiative.

This issue of the AFIT Annual Report features the outstanding work of our researchers in the Department of Aeronautics and Astronautics under the leadership of Professor and Department Head, Dr. Bradley S. Liebst. Faculty research interests include: aerospace structures and materials, control of high-performance aircraft and remotely piloted aircraft (RPAs), spacecraft and satellite cluster dynamics, navigation and control, and propulsion.

As we celebrate our 90th anniversary, AFIT continues to build upon a solid foundation of focused research to support our military infrastructure and other government agencies. I think you will agree that the articles in this issue are a testament to the leadership of our faculty, staff and students, and that they illustrate how we deliver solutions to complex technical problems in order to support our military and make the world a safer place.

Respectfully,

Marlin U. Thomas, PhD
Dean, Graduate School of Engineering and Management
Air Force Institute of Technology

Cover photo by Christopher Zickefoose, First Place Winner, Art-in-Science Award, Dayton-Cincinnati Aerospace Science Symposium. A Hall-effect thruster operating with xenon propellant produces exhaust velocities in excess of 18 km/s! Using a combination of electromagnetism and classical physics the Hall-effect thruster ionizes the xenon gas, which acts as the propellant, and accelerates it to generate thrust. The small amount of neutral purple plasma to the right of the highly ionized blue plasma plume is from the cathode which provides electrons to both ionize the propellant inside the channel of the thruster and neutralize the exhaust plume.

AFIT
The Air Force Institute of Technology

Air Force Institute of Technology Celebrates 90th Year

On November 10, 1919, the first official class of the Air School of Application convened at McCook Field in Dayton, Ohio. Later renamed the Air Force Institute of Technology, the first class was attended and led by Lieutenant Edwin Aldrin. Aldrin's son, Buzz, would later attend AFIT and make history as one of the first people to walk on the moon. Colonel Thurman Bane was AFIT's first commandant and was recognized by current Commandant, Brigadier General Walter Givhan, at the Institute's 90th Anniversary celebration. The school was the vision of Colonel Bane who was the Executive Officer of the Air Division. Colonel Bane wrote to the Director of Military Aeronautics in Washington, D.C. seeking authorization for an Air Service School. He was granted authorization and the institute was born and quickly became instrumental in the development of air power to support our two world wars. Since that time, AFIT has played a major role in national defense and in education that is centered on research to support the warfighter.

In addition to the Aldrins, AFIT claims a number of distinguished alumni including General Jimmy Doolittle (1923), General Bernard Schriever (1941), and Captain Gus Grissom (1956). The institute now has three resident schools: the Graduate School of Engineering and Management, the School of Systems and Logistics, and the Civil Engineer School. All three schools hold the primary mission of educating students so that they possess the skills necessary to succeed in the rapidly changing strategic and technological environment of today's Air Force.

For more information on AFIT, visit www.afit.edu

AFIT Welcomes New Commandant

AFIT welcomed its 46th Commandant at a ceremony on October 6th. Brigadier General Walter D. Givhan joins AFIT after a year of serving as the Commanding General, Combined Air Power Transition Force, Combined Security Transition Command-Afghanistan, Kabul, Afghanistan. Upon assuming command at AFIT, Commandant Givhan noted that educating soldiers, sailors, airmen, Marines and civilians is important. “The longer I serve, the better I understand the big picture—the history, hard work, and genius that goes into making our nation a leader in air, space, and cyberspace power—the better I understand the role of institutions such as AFIT in making that come to pass.”

Commandant Givhan is a native of Safford, Alabama and a graduate of the Morgan Academy in Selma, Alabama. He earned a bachelor’s degree in history from the University of the South in Sewanee, Tennessee where he was a National Merit Scholar. Additionally, he holds a master’s degree in international relations from Troy State University and a master’s degree in airpower art and science from the School of Advanced Airpower Studies (SAAS). He served as the U.S. air liaison officer to the commanding general, French ground forces, for operation Desert Shield and Desert Storm. The general has commanded a combat training squadron, an operations group, an air base wing, and an air expeditionary wing during his 28 year career with the Air Force. He is a pilot with more than 2,500 flying hours.

AFIT Mission Statement

“*Provide defense-focused technical graduate and continuing education, research, and consultation for air, space, and cyberspace competence.”*

Tau Beta Pi Chapter Celebrates 50th Anniversary

The Ohio Eta Chapter of Tau Beta Pi is celebrating its 50th year. Since its inception in February 1959, the Eta Chapter of this eminent engineering honor society has inducted nearly 1,900 members. Those inducted into the chapter have excelled at AFIT in one of the most rigorous and demanding engineering programs in the nation. A celebration was held on December 9th and a plaque was presented from Tau Beta Pi National headquarters.

Tau Beta Pi was founded in 1885 “to mark in a fitting manner those who have conferred honor upon their alma mater by distinguished scholarship and exemplary character as undergraduates in the field of engineering, or by their attainment as alumni in the field of engineering, and to foster a sprit of liberal culture in the engineering colleges.”

AERONAUTICS & ASTRONAUTICS

Department of Aeronautics & Astronautics

"Aircraft and spacecraft play a crucial role in the Air Force's defense of our nation. The faculty and staff in the Department of Aeronautics and Astronautics are all dedicated to producing graduates and research that assures the future aircraft and spacecraft needs of the Air Force will continue to be met. The department conducts basic and applied research in: low and high speed aerodynamics, propulsion, structural mechanics, materials science, and dynamics and control as they pertain to aircraft and spacecraft." —Dr. Bradley Liebst, Professor and Department Head

http://www.afit.edu/en/eny/index.cfm

Mission of the Aeronautics and Astronautics Department

"*Provide high-quality aerospace graduate education and to conduct world-class defense focused research."*

Departmental Data

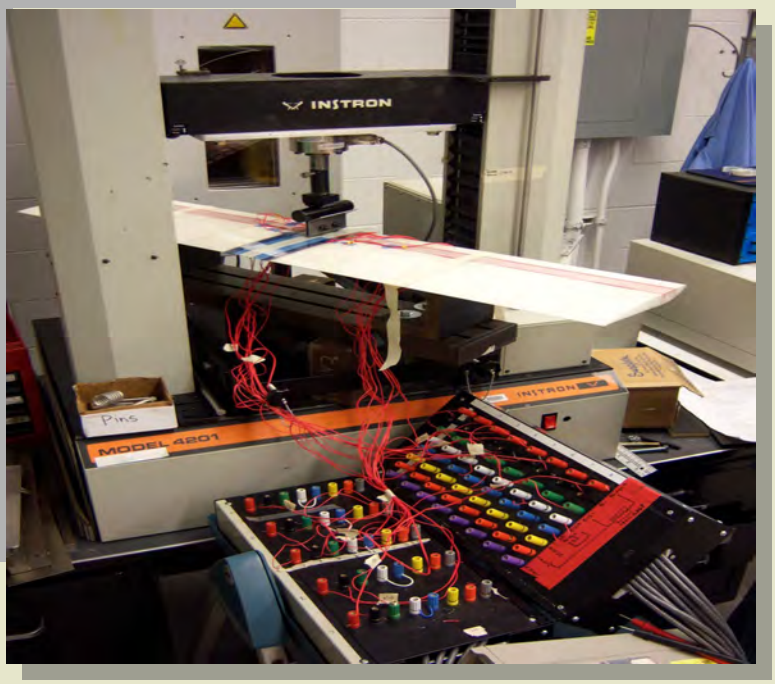
- Master's: 166
- Doctoral: 24
- Certificate: 33
- Faculty: 21
- Professional Society Fellows: 4
- Publications for 2009
  - Refereed Journals: 50
  - Dissertations: 10

The Department of Aeronautics and Astronautics has been offering education in Aeronautical Engineering since 1951. In addition to Aeronautical Engineering, the department offers degrees through the doctoral level in Astronautical Engineering, Materials Science, Space Systems, Mechanical Engineering, and Engineering Mechanics. The Master of Science programs in Aeronautical Engineering and Astronautical Engineering are accredited by ABET (Accreditation Board for Engineering and Technology). The North Central Association of Colleges and Universities accredits all other master's and doctorate level degree programs. The department has three major areas of expertise:

- The Fluid Mechanics and Energy Transmission Division provides courses and opportunities for research in aerodynamics, propulsion, and heat transfer.
- The Solid Mechanics and Structures Division provides course offerings and research programs covering applied mechanics, structures, structural dynamics, and structural materials.
- The Dynamic Systems and Controls Division provides courses and research activities in aircraft flight mechanics, astrodynamics, spacecraft attitude, dynamics, systems, and robotics.

AFIT X-HALE Prototype Supports DARPA Vulture Program

Large aerospace companies engaged in building aircraft to support DARPA's $300 million Vulture program need to look no further than AFIT to find research and prototypes to support their design and development activities. During the last year, AFIT's Aerospace Engineering group has been working with the Air Vehicles directorate (AFRL/RB) and the University of Michigan to develop a scaled experimental high-altitude long endurance (HALE) aircraft. With a wing span of 6 meters, a chord of 20 centimeters, and a gross weight of 9 kg, the aircraft is designed to be highly flexible, representing a new concept in the next generation of intelligence surveillance and reconnaissance (ISR) platforms. The objective of X-HALE is to collect flight test data which will be used to validate nonlinear aeroelastic aircraft design codes.



DARPA's Vulture Program has a goal of building aircraft that fly like an airplane, operate like a satellite, and can be airborne for five continuous years. These aircraft will be positioned at locations around the world for ISR tasking. The validation and continued development of nonlinear aeroelastic design codes is similar to the problems faced in early aviation development. In the late 1800s the Wright brothers lacked good aerodynamic data to design flying machines, so they took it upon themselves to develop theories and build testing prototypes in order to capture the information needed to build their aircraft. Similarly, AFIT is developing the X-HALE aircraft to provide persistent ISR, and this new generation aircraft requires data and theories not supported by traditional aircraft design. The first of two X-HALE aircraft was delivered in October 2009 and flight testing completed at the end of November. The initial vehicle was built and flown as a risk reduction aircraft, the second vehicle, tasked with data collection, is expected to be deployed in early 2010.

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Low Cost Sensor for Multiple Missions

Remote sensing, electro-optical (EO) technologies not only serve to assist the warfighter, they are useful in a wide range of civil applications including natural resource management. Unfortunately, current EO payloads typically require a point design in which spectral, spatial, and temporal resolution are set prior to launch and either cannot be altered in orbit, or can only be changed within a small range. EO sensors built for specific missions such as detecting camouflaged tanks through trees are optimized for the particular undertaking and may not be useful in performing other tasks.

A multi-disciplinary team from the Aeronautics and Astronautics and Engineering Physics Departments at AFIT seeks to solve this problem. The faculty and students plan to develop and fly the space chromotomographic experiment (CTEx). The CTEx space flight experiment will demonstrate the utility of this type of simple, low-cost sensor to perform multiple remote sensing missions in orbit. The instrument itself is very simple relative to other spectrometers, consisting of a standard optical telescope, a rotating prism, and a camera. The CTEx space flight experiment will demonstrate the flexible, low-cost potential of these sensors by being the first to perform multiple remote sensing missions.

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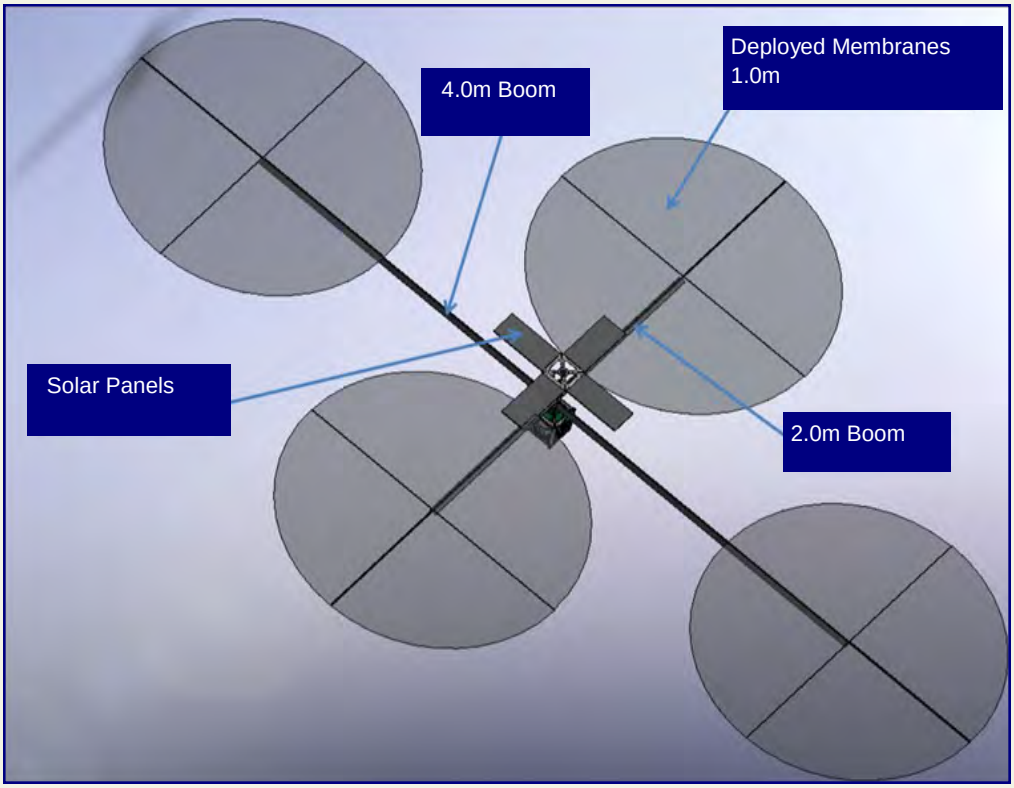
Small Satellites for Rapid Response

Could tiny satellites smaller than a loaf of bread someday play a major role in our space and missile defense program? Dr. Jonathan Black and his students think so and are focusing their research efforts on Strain-energy-deployed Lightweight Mast CubeSats (SLiMSat). CubeSats are a subset within the greater body of satellite designs. A CubeSat is a one liter volume (10 x 10 x 10 cm), one kilogram small satellite built using commercial off-the-shelf electronics. Dozens of CubeSats are launched successfully every year by universities and enthusiasts expanding the usefulness of this type of spacecraft platform beyond the walls of academia into commercial and DoD applications.

Scientists are attempting to set a standard bus size and volume to take advantage of common integration and launch platforms. To achieve the desired functionality for these missions, deployable booms, solar arrays, and apertures on CubeSats are required. Putting them together efficiently, and post deployment accuracy are critical metrics for mission success.

Dr. Black and his team are building the Strain-energy-deployed Lightweight Mast CubeSat (SLiMSat). The goal of the research is to enhance the capabilities of low cost, rapidly assembled small satellites and develop the science of networking commercial ground-based telescopes for enhanced low Earth orbit (LEO) space situational awareness (SSA).



The research program will build, launch, and operate SLiMSat to demonstrate the deployment of large structures from very small satellites. These structures will enable deployable apertures and solar arrays much larger than currently possible in small satellites, greatly increasing their functionality. Once launched, multiple synchronized ground-based commercial telescopes will image SLiMSat's large deployed membrane structures to develop this type of imaging as a tool for LEO SSA. This mission will be the first in a series launched by AFIT, with the annual goal of designing, building and flying a CubeSat each year to enable regular evolutionary testing of technologies that will enhance the capabilities of small satellites to perform remote sensing missions.

This work at AFIT is unique and innovative in that it brings together three research tasks necessary for advancement of the field. It validates small satellite deployable technologies, it supports the development of ground imaging for SSA, and finally it is an on-orbit measurement system for deployed geometries. These tasks individually advance the state of the art in their respective fields, but accomplishing all three in a single effort brings great value for the research dollars spent.

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AFIT Alum Pilots Space Shuttle Mission to the International Space Station

Dr. Kevin Ford (Colonel, USAF, Ret.) is the 12th AFIT Resident Graduate School alum to become an astronaut. Dr. Ford, 49, piloted the Space Shuttle Discovery STS-128 mission to the International Space Station to deliver supplies and equipment. The Space Shuttle launched on Friday, August 29th, 2009, from NASA's Kennedy Space Center in Florida.

According to a September 2009 NASA press release, during the 14-day mission Discovery's crew delivered more than 7 tons of laboratory facilities, the COLBERT treadmill, food, water, and other supplies to the space station; and over the course of three spacewalks, replaced an ammonia tank critical to station cooling and retrieved material samples that will help with new spacecraft development.

Ford received his PhD in Astronautical Engineering from AFIT in 1997. His faculty advisor was Dr. Christopher D. Hall, also an AFIT alum (M.S. Systems Engineering, 1988), who now heads the Department of Aerospace and Ocean Engineering at Virginia Polytechnic Institute and State University in Blacksburg, Virginia. Dr. Hall believes that Ford's dissertation, *Reorientations of Flexible Spacecraft Using Momentum Exchange Devices,* helped him better understand spacecraft motion. He remains in contact with Dr. Ford and received emails from him during the mission discussing attitude motion of the space shuttle and how they controlled pointing and issues with thrusters.

Dr. Bradley Liebst, head of AFIT's Aeronautics and Astronautics Department, sent Dr. Ford a U.S. flag to take with him on his shuttle mission. Dr. Liebst is planning a visit to AFIT by Dr. Ford, including a talk and presentation of the flag to be incorporated into a display honoring AFIT's astronauts.

AFIT Alumni Makes Fifth Shuttle Flight

Veteran shuttle commander and retired Air Force Colonel Steven W. Lindsey will command his fifth shuttle flight, an eight-day mission designated STS-133. He served as the pilot of STS-87 in 1997 and STS-95 in 1998, and commanded STS-104 in 2001 and STS-121 in 2006. To date, Commander Lindsey has logged over 1,203 hours in space.

During his career he has been awarded the Distinguished Flying Cross Defense Superior Service Medal, Defense Meritorious Service Medal, three NASA Space Flight Medals, NASA Outstanding Leadership Medal, NASA Exceptional Service Medal, Air Force Meritorious Service Medal, Air Force Commendation Medal, Air Force Achievement Medal and Aerial Achievement Medal.

Targeted to launch in September 2010, the flight will carry a pressurized logistics module to the space station. Commander Lindsey earned a M.S. in Aeronautical Engineering from AFIT in 1990.

Space Situational Awareness

Dr. Richard Cobb and AFIT graduate students in the department of Aeronautics and Astronautics are developing satellite-tracking telescope systems—a critical enabler for Space Situational Awareness (SSA). Their work satisfies two key goals of the U.S. Air Force space program. First and foremost, the research helps the U.S. Air Force tackle relevant operational challenges. Second, the work provides U.S. military space professionals with opportunities to develop in-depth technical understanding, a critical element in maintaining and sustaining America's space power. By using learned skills in orbital mechanics, control theory, and systems engineering, students are applying their knowledge firsthand to identify and expand upon opportunities to improve SSA.

Initial research employed a low-cost commercial telescope to explore orbit determination techniques for Low Earth Orbit (LEO) satellites using angles-only methods. During this phase, the telescope's control software featured SGP4 propagation, common brightness modeling, and a student developed interactive control interface written in the MATLAB programming environment. Ongoing research includes exploring imaging concepts to produce resolved images of LEO satellites. Select LEO satellites have been filmed, and a number of publicly available post-processing programs have been used to apply frame selection algorithms and image stacking techniques. A closed-loop feedback control is being added to the software controller to improve the telescope's continuous tracking accuracy and autonomy. Future plans include exploring the ability to produce real-time orbit estimates with a second cross-queued networked telescope. A sliding-roof observatory installed at the AFIT complex is used to house the telescope system. This new testbed provides AFIT Aeronautics and Astronautics Engineering students a hands-on environment that complements their coursework in learning space science.

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Terrain Avoidance Research

In the past few years, Gravity Gradient Instruments (GGIs) have improved dramatically. These devices are used to measure the spatial derivatives of gravity. Specialized GGIs are currently flown on aircraft for geological purposes in the mining industries. Gravity gradient data is recorded in flight with detailed gradient maps being created after post mission processing takes place. These maps can then be stored in an onboard database on the aircraft and, in theory, combined with newly acquired GGI data to form the basis for a covert navigation system which uses a map matching process. This type of system is completely passive and therefore essentially unjammable.

Captain Marshall Rogers, working under faculty advisor Dr. Richard Huffman, tested the feasibility of this method for his master's thesis research at AFIT. He developed a GGI sensor model to investigate signal levels under representative flight conditions. His conclusion was that GGI based map-matching navigation systems can likely provide marked improvement over non-aided inertial navigation systems, but is limited by decreasing gravity gradient strength at higher altitudes. Captain Roger's thesis was recognized with a Blue Dart Award by Air University.

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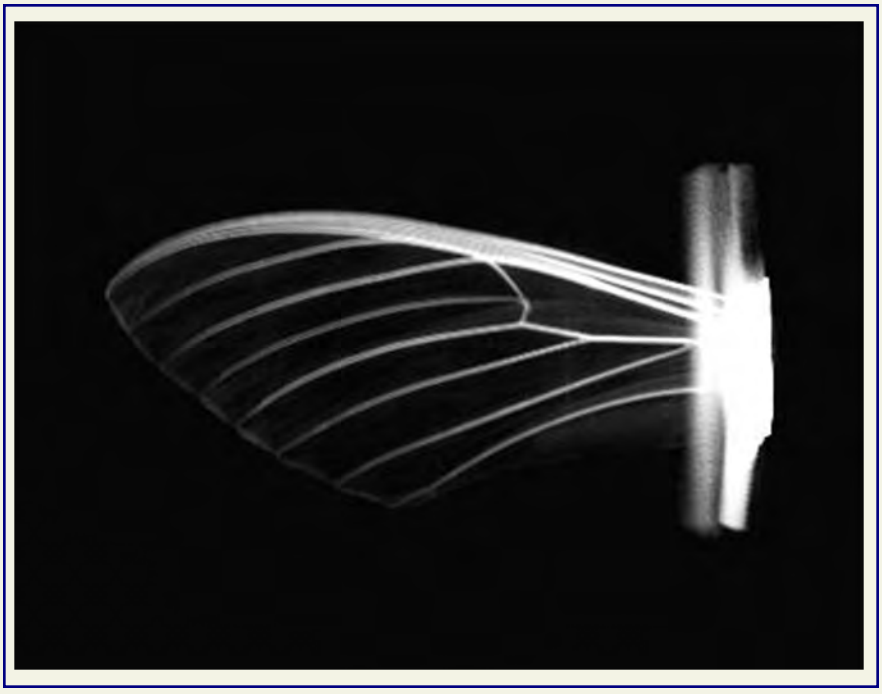
Insects Inspire Scientists

Could studying the structural properties of moth wings give the U.S. military a strategic edge on the battlefield of the future? Studies by a team of researchers at AFIT are paving the way towards realization of the Air Force's vision of operating insect-sized micro air vehicles (MAVs) by the year 2030. An order of magnitude smaller than current MAVs, these small devices will achieve flight by flapping their wings—unlike their fixed wing, propeller driven predecessors. In fact, if the vision is fully realized, they will so closely mimic the behavior of their biological inspirations that they will be able to carry out covert operations in plain sight.

The technology has the potential to provide the warfighter with a "fly-on-the-wall" perspective of urban battlefields as well as the ability to follow foes deep into their subterranean hiding places. Because these small engineered vehicles will have characteristics similar to their bio-inspired counterparts, they are ideally suited for operations in urban, indoor, and tight corridor spaces. However, as team leader Dr. Anthony Palazotto concedes, "mimicking the performance of nature's miniature flyers in no easy task and only recently have strides been made towards an understanding of the underlying physics of their aerial maneuvers." Dr. Palazotto's team has set out to develop a high-fidelity structural model of an insect wing. Once realized, this groundbreaking model could serve as a baseline for future design studies and ultimately shed new light on the nature of insect flight.

The team selected the hawk moth (*Manduca Sexta)* as a basis for study given its relatively exceptional performance, availability of specimens, and volume of supporting research within the scientific community. Structural tests are conducted on biological specimens from a colony of hawk moth maintained by Willis Lab at Case Western University. The testing, which uses a scanning laser vibrometer, reveals the underlying structural dynamic features of the moth wings. The vibrometer is able to measure the wing's reaction to small vibratory motion by analyzing the reflected properties of a laser beam pointed at hundreds of locations across the wing's surface. Because of its light weight and delicate nature, the wing's structural response is largely obscured by action of the surrounding air, testing is carried out in a table-top vacuum chamber with large acrylic panes. With experimentally determined structural dynamic parameters in-hand from the test, x-ray images using a CAT scan machine provide high-fidelity 3-D geometry measurements of the wing that are used to create computer models of the wing's structure. The data from testing is used to ensure that this computer model is an accurate representation of the biological wing specimen.



So far the team's research has revealed that hawk moths, regardless of their size, share a common underlying structural dynamic behavior. What's more, similar testing carried out on a few species of butterfly show that they exhibit the same behavior. This observation could imply that these features are required for the flight of both moths and butterflies. If Palazotto's team is able to confirm that these common structural "traits" are indeed prerequisites for flight, then designers who have looked to moths and butterflies for design inspiration could mimic such traits in their engineered wing designs. In addition, by using cutting-edge photographical measurement techniques, the team has recently uncovered the most compelling evidence to date that the flight of hawk moths is characterized by aeroelastic phenomenon; one in which the wing's structural response determines its aerodynamics, which in turn determines the wing's structural response. This is an important finding all in its own since it refutes prior claims that the wing's response is not aerolastic in nature. Not only does this finding provide better insight into the nature of insect flight, it confirms that similar analysis tools can be used to analyze and test aerodynamic and structural wing response for the design of more sophisticated aircraft.

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Optical Forensics to Combat the IED Threat

The improvised explosive device (IED) poses a significant problem for the warfighter in Afghanistan and Iraq. One of the Joint IED Defeat Organization's primary goals is defeating the network of enemy combatants responsible for manufacturing, placing, and detonating these weapons. A standard forensic investigation following an IED attack has the potential to reveal important information about how a particular weapon was constructed, yet because of the personnel risks posed by forensic analysis in the theatre, critical information about IED construction goes largely uncollected.

To address this problem, Dr. Kevin Gross, Assistant Professor of Engineering Physics, and the Remote Sensing Group in AFIT's Department of Engineering Physics is employing battlespace sensors and utilizing physics-based methods to extract forensic information from radiation emitted by exploded IEDs. AFIT PhD students involved in this effort include Captain Ken Bradley, USAF, Major Joe Gordon, USAF, and Mr. Chris Rice, a full-time civilian student. Researchers draw from sources both internal and external to AFIT to identify "signatures" specific to particular IED devices. Predictive models are developed at AFIT and tested against data gathered at various DoD test ranges throughout the U.S. Initial studies have resulted in the development of an infrared fireball emissions model, and faculty and students have been able to successfully discriminate between various types of IEDs based on chemical composition and size. These advances in optical forensics serve as the foundation for building ever increasingly sophisticated instrumentation to assist the warfighter in the field, and they could potentially provide the Intelligence Community with new technology-based tools to track the transport of materials used to build IEDs.

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AFIT Plays Critical Role in ISR Capabilities Enhancement

AFIT's Department of Operational Sciences has been called upon to participate in a high-level landmark project with the goal of upgrading overall intelligence, surveillance, and reconnaissance (ISR) capabilities. An Air Force briefing earlier this year revealed that current airborne resources, such as the MQ-1 remotely piloted aircraft, were not keeping up with increasing demands for intelligence, surveillance, and reconnaissance information. This, along with a 2008 Congressional mandate to develop new ISR capabilities to meet future needs, became the impetus leading to AFIT's involvement in this joint service initiative.

A necessary step in proposing and developing new ISR capabilities from competing options, is to first quantifiably, accurately, and reliably define future needs, and then to evaluate the best combination of ISR resource types (imagery, signals, communications, etc.) to meet these future requirements. AFIT's Department of Operational Sciences is providing the needed expertise in several operations research areas required to construct this landmark future-needs evaluation model. The product of this work, which has been briefed to the Vice Chairman of the Joint Chiefs of Staff, is now being validated through real-world applications. AFIT contributions will improve the rapid deployment and fielding of joint ISR solutions, help define ISR needs, standardize evaluation of ISR requirements, and steer development and future budget decisions.

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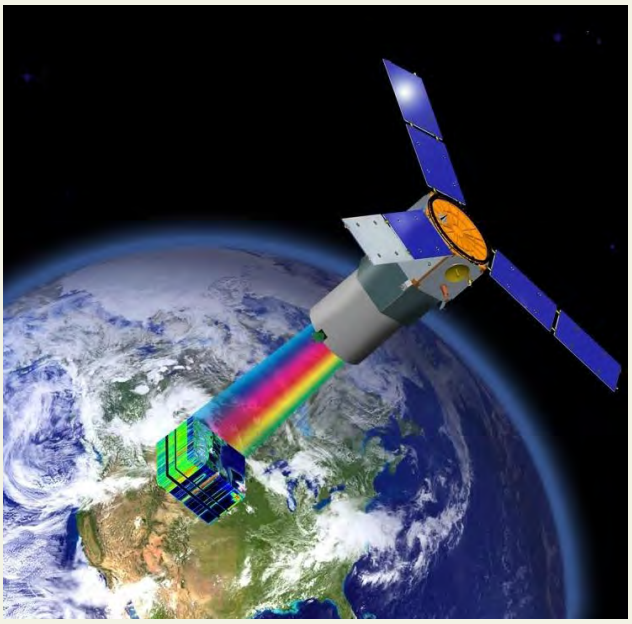
AFIT Thesis Research is Out of This World



Captain Robert J. Johnson, a March 2008 Department of Operational Sciences graduate, can rightfully claim that his thesis research is "out of this world." Computer code developed by Captain Johnson under advisor Dr. Kenneth W. Bauer, Jr. has been successfully transitioned to the intelligence community and into outer space. The code, AutoGAD, was used as part of an analysis software suite developed by the National Air and Space Intelligence Center (NASIC) to support the R & D system, TacSat-3. Launched in May 2009, the Tactical Satellite-3 spacecraft featured an onboard processor capable of providing real-time data to the combatant commander within ten minutes of collection. The mission's primary experiment, the Raytheon Company's ARTEMIS HSI, rapidly integrates detection and identification data, battlefield preparation information, and combat damage assessment. AUTOGAD supported this primary mission through its unique ability to detect anomalies in hyperspectral imagery. Captain Johnson's thesis received the Graduate School's Commandant's Award.

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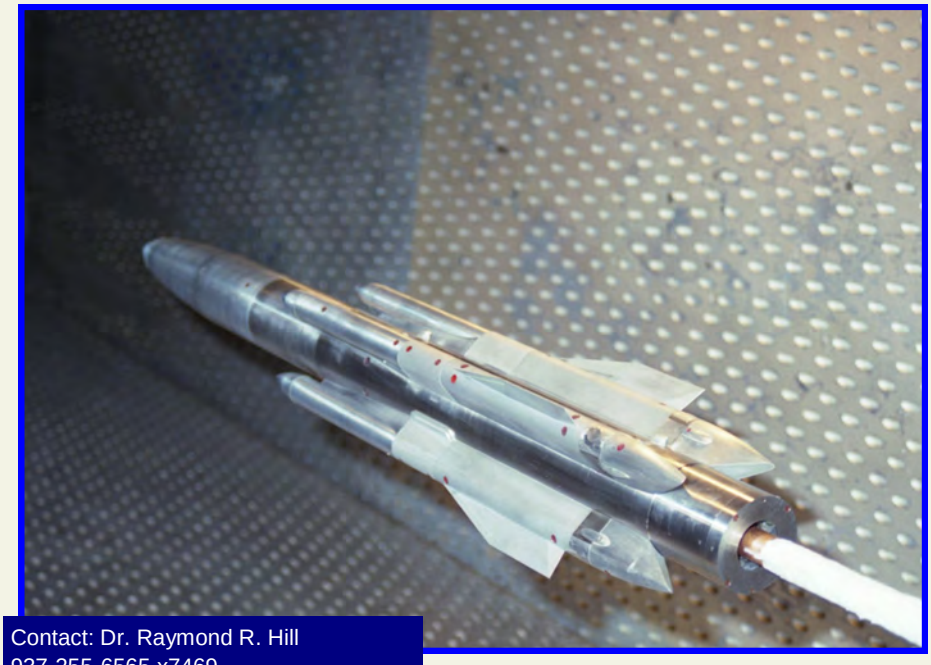
AFIT Scientists Team with AEDC to Reduce Testing Costs

Wind Tunnel testing is critical in Developmental Test and Evaluation (DT&E) for a wide range of systems, often uncovering design problems early in the acquisition process. While the abundance of data generated during wind tunnel campaigns are essential for subsequent design analyses, test analyses, and operational performance assessments, these campaigns require significant resource expenditure. AFIT Department of Operational Sciences researchers are supporting Arnold Engineering and Development Center (AEDC), a unique world-class wind tunnel test facility, by examining how the design of experiments might reduce wind tunnel campaign design point requirements without impacting the level and quality of information generated in the campaign. AFIT researchers use advanced experimental design techniques applied to the results of large-scale wind tunnel campaigns to quantify potential information loss due to experimental design methods. The research compares empirical models describing actual wind tunnel data and empirical models built using more parsimonious, advanced experimental designs. Analytical, graphical, and statistical comparisons of models show no discernable loss of information despite a nearly 90% reduction in the number of experimental design points. Such savings in experimental effort can then be made available to improve other areas of wind tunnel experimental processes in future wind tunnel T&E.



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New Civil Engineering Research WIKI Established

What is in a wiki? For the Air Force engineering community, it's the latest information on civil engineering research. The wiki concept has become increasingly popular in recent years as a way for communities of researchers to share, discuss, review research in progress, and publish via the web. A wiki also can serve as an electronic repository for completed work. The brain-child of Major Peter Feng in the Department of Systems Engineering and Management, the wiki is the first-of-its-kind for the military civil engineering community. It is accessible through the Air Force Portal and Air Force Knowledge Now. Anyone with access to these systems, and an interest in civil engineering, can participate in discussions and publish on the wiki site which is maintained and updated collaboratively by the community members.

In addition to member submissions, the wiki currently contains abstracts of AFIT civil engineering theses and dissertations from the past two years. Major Feng plans to include full .pdf versions of dissertations as they become available. In an announcement from Major General Timothy A. Byers. The general encourages "all Field Operating Agency (FOA), Major Air Force Command (MAJCOM), and Headquarters Air Force staffs (HAF) to use the academic research to its fullest potential in order to meet tough present and future challenges." Please link to https://afkm.wpafb.af.mil/ASPs/CoP/OpenCoP.asp?Filter=OO-MS-AE-40 for access to the wiki.

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Improving Weapon System Sustainment And Logistics Support

Supply Chain Management within the defense industry, as with commercial enterprises, is continuously evolving. Understanding these changes is critical to ensuring future weapons systems sustainment and logistics support. AFIT's Department of Operational Sciences' Logistics Management Division is leading a two-year study on future logistics and supply chain management trends for the Air Force Research Laboratory's ManTech division.

During on-site interviews with both private sector and defense industry thought leaders, the team will review practices in logistics, purchasing, production, research and development, finance, marketing, and sales. The AFIT Team will focus on identifying best practices in logistics and supply chain management. Special emphasis will be placed on identifying emerging short-term (1-4 years) and long-term (>4 years) practices that can be adapted by the Air Force in order to provide operational commanders with sustainable and maintainable weapons systems.

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Next Generation Plume Diagnostics

AFIT researchers are developing next-generation plume diagnostics with the help of a one-of-a kind instrument. The Engineering Physics department recently acquired the nation's only field-deployable, high-speed, midwave infrared imaging Fourier-transform spectrometer (IFTS). AFIT's Remote Sensing Group has been pushing the limits of ultraspectral imagery and demonstrating its unique capabilities for combustion diagnostics. The high spatial and spectral resolution—up to 0.25 cm^{-1} on more than 80,000 pixels—enables characterization of combustion plumes and other extended objects with unprecedented detail. Designed by the Canadian company Telops Inc., the IFTS is a Michelson interferometer coupled to a custom, high-speed infrared focal-plane array originally developed for the Starfire Optical Range at Kirtland AFB. Its rugged, field-deployable nature makes it possible to observe high-value targets such as exhaust plumes from rockets and military aircraft.

This unique asset has enabled two important research thrusts involving plumes: (1) combustion diagnostics for turbulent plumes from aircraft and rockets and (2) smokestack emissions for environmental monitoring. The high spectral resolution enables identification of various combustion byproducts and determination of their concentrations and temperature. Determining these key parameters at each pixel reveals their spatial variations with high-fidelity. With statistical processing of the interferograms—the fundamental measurement from an IFTS—it is even possible to estimate the size of temperature fluctuations caused by turbulence. The Remote Sensing Group is developing and demonstrating these capabilities using realistic targets. Recent ultraspectral measurements by AFIT's IFTS include (1) radiation from the exhaust of an F-16 in afterburner, (2) plume emissions from an Atlas V rocket launch, (3) and smokestack emissions from a coal-burning power plant. These unique data sets from this one-of-a-kind instrument are enabling AFIT students and faculty to develop next-generation plume diagnostics.

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Over-the-Horizon-Radar Trial Conducted at AFIT

Under the supervision of Dr. Andrew Terzuoli in AFIT's Electrical Engineering department, student researchers Lee Burchet, John Cetnar, and Dave Chick have collaborated with Riverside Research Institute in designing and building OSIS, on over-the-horizon (OTHR) support instrumentation suite for the Air Force. OSIS exploits commercial off-the-shelf digital hardware to assess the limits in detection performance of OTHR systems. This information is vital for the military when making expensive hardware and systems upgrade decisions. OSIS provides up to 16 independent channels of high dynamic range, direct digital high-frequency arbitrary waveform generation and narrowband reception, as well as wideband recording and display capability. The OSIS equipment was tested on high-frequency circuits between several transmit sites and a receive site at AFIT. Work continues on the system with AFIT providing the venue, faculty, and student resources—an important component in moving the mission toward success.

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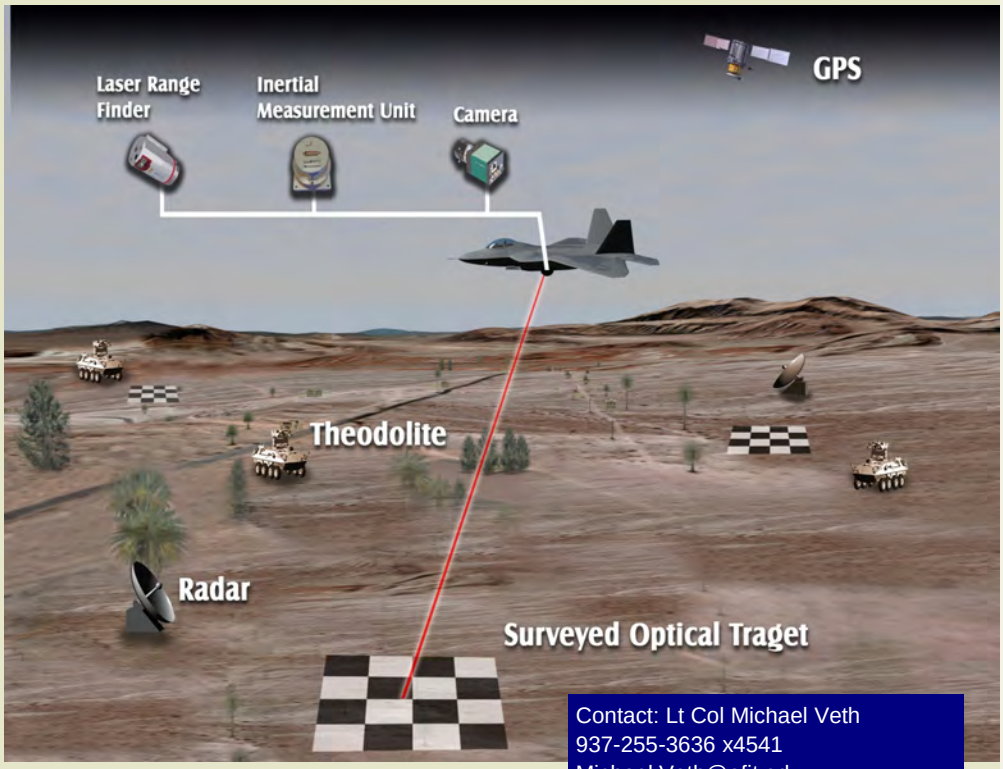
Next Generation Navigation Reference System

AFIT's Advanced Navigation Technology Center (ANT) has been tasked with a significant role in building the next generation flight reference system for the Air Force Flight Test Center (AFFTC). The purpose of the flight reference system is to stay one step ahead of current avionics systems by providing navigation information with unmatched accuracy. When navigation instruments and sensors are flight tested, their navigation output is evaluated based on the flight reference system. AFFTC designed the first flight reference system in 1994, but with the increased accuracy and capabilities of modern avionics systems, the gap has been closed between the original AFFTC reference system and currently deployed navigation systems. Without a significant accuracy advantage, the flight reference system becomes an insignificant metric for modern platforms.

To solve this problem, the ANT Center has been tasked with investigating new sensors and techniques that can be used in an upgraded reference system. Lieutenant Colonel Michael Veth and research engineer, Mark Smearcheck are developing algorithms that will simulate advanced sensors flying onboard a test aircraft collecting navigation data. In addition to traditional GPS and inertial navigation systems, the ANT Center is testing the next generation prototype with high-resolution digital cameras for feature tracking, onboard lasers for long distance measurement, and ground based sensors such as radars, lasers, and cameras for tracking aircraft during flight. The results of these simulations will help AFFTC build the next generation flight reference system.



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Optical Scatter Laboratory Upgraded

For a soldier in the field, accurate target recognition and background discrimination may mean the difference between life and death. To make these assessments, the military employs a variety of sensors as part of various warfighting technologies. Developing sophisticated sensors requires background research now being conducted by AFIT's Department of Engineering Physics. The department has significantly upgraded its Optical Scatter Laboratory during 2009. The baseline system, the Complete Angle Scatter Instrument (CASI) built by Schmitt Measurement Systems, Inc., has been used to make bi-directional (i.e. distinct incident and scatter angles) measurements of both the transmission and reflection of light at four distinct wavelengths, 544 and 633 nm and 3.39 and 10.6 μm. The Engineering Physics department added six tunable external-cavity quantum-cascade lasers (EC-QCL's) to the CASI to give it very unique tune-ability across the infrared (IR) at 4.4-6.5 and 7.4-9.7 μm. Also, previous polarimetric scatter measurements were limited to only linear polarizations at the three lowest basic laser wavelengths. Now the CASI has been converted into a fully automated dual-rotating retarder Mueller-matrix (DRR-Mm) polarimeter to collect full Stokes-vector polarization information in the visible and IR.

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AFIT Develops Nuclear Concentration for Air University Online Degree Program

AFIT faculty members are taking a leadership role in designing a nuclear concentration component for the Master of Military Operational Art and Science online master's degree program offered through Air University. Once fully implemented, this program will provide USAF Captains with the opportunity to earn a master's degree as part of the completion of their Intermediate Development Education requirements. The nuclear concentration is one of four included in the program, the others being Joint Warfighting, Leadership, and Operational Warfighting.

The nuclear concentration will become available in the summer of 2010. Courses in the concentration area will cover nuclear operations, nuclear strategy, nuclear policy, and nuclear weapons implementation. The courses are designed for non-technical officers, and they do not require differential calculus or modern physics as a prerequisite. The courses draw from materials used in AFIT's masters and PhD program in nuclear engineering offered within the Department of Nuclear Engineering Physics. Besides building AFIT's capability in developing distance learning curriculum, the institute will benefit overall from the infusion of non-technical nuclear expertise—a key area of interest for the Air Force.

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STEM Students Engage in High Energy Laser Research

The Center for Excellence in High Energy Lasers (COEHEL) was established in 2006 as an educational partnership between AFIT, the Air Force Office of Scientific Research (AFOSR), the University of New Mexico and New Mexico Tech. Based at the Air Force Research Laboratory (AFRL), Directed Energy Directorate at Kirkland AFB, the Center seeks to expose graduate and undergraduate STEM (Science, Technology, Engineering and Math) students to DoD high energy laser technology in hopes of stimulating their interest in a government service career. The Center funds student graduate research through monies provided by AFOSR and AFRL—last year totaling almost a million dollars. In addition, a multi-disciplinary research initiative funded by the High Energy Laser Technology Office brings another $350K per year to the Center's research programs. Since its inception, the Center has served nineteen PhD and six master's students. AFIT plays a crucial role in the program of managing the COEHEL staff and supporting the mission through research conducted by AFIT PhD and master's students as well as undergraduate civilian research assistants.

Symposium Addresses CBRNE Research and Education Concerns

According to the Department of Homeland Security, chemical, biological, radiological, nuclear and enhanced conventional weapons (CBRNE) are a major concern for citizens and government officials nationwide. For the past three years, AFIT and Wright State University have joined together to present the Annual Midwest CBRNE Research and Education Collaborative Symposium. Researchers and others interested in participating in the 2010 conference should look for upcoming details at http://www.afit.edu/en/env/index.cfm or contact the Systems and Engineering Management Department, 937-255-3636 x2998.

FACULTY NOTES

AFIT Patent for Software Protection

A major challenge in the battle to secure computers and other devices is to stay current with the ever changing profiles of viruses, worms, backdoors, and other malicious code collectively known as malware. Historically, security applications have worked by identifying characteristics of bad code and "blacklisting" identical or similar code. Unfortunately, it can take hours or days before this information is incorporated into security applications, and some malware has the ability to "morph" rendering it unrecognizable to a security application. When this happens a system can become infected and data can be compromised.

Dr. Rusty Baldwin of the Center for Cyberspace Research has patented a new approach. His emulation-based software protection scheme guards software in two ways. First, it secures the intellectual property of software by keeping programs encrypted until just prior to execution. Second, instead of blacklisting undesirable code, Dr. Baldwin's approach uses a "whitelist" of certified and trusted sources. Only whitelisted code is executed so the system and data are protected. According to Dr. Baldwin, the technology has implications for DoD-wide computer security with the potential to stop virtually all code injection attacks.

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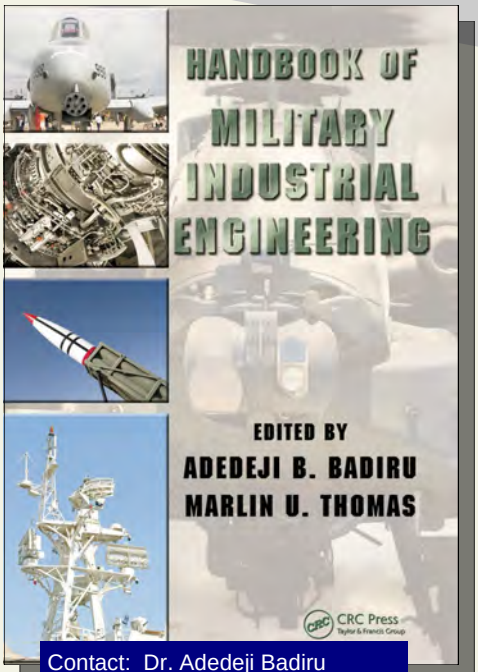

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Koopman Prize

Recent AFIT PhD graduate, Lieutenant Colonel Dr. Todd Hamill, PhD and faculty members, Dr. Richard F. Deckro, Dr. Robert F. Mills and Dr. James W. Chrissis were named winners of the Koopman Prize for their publication, "Research-Based Assessment of Position," published in the journal *Military Operations Research* (Vol 13, No. 4, pp 59-78, 2008). The prize is awarded annually by the Military Applications Society of the Institute of Operations Research and Management (INFORMS), the largest professional society in operations research, for the best paper or report in the field. The prize was named after Bernard Koopman, a founding father of military operations research.

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Industrial Engineering Book of the Month

The *Handbook of Military Industrial Engineering* was chosen by *Industrial Engineering Magazine* as the August 2009 book of the month. Edited by AFIT department head, Dr. Adedeji Badiru and Dean, Dr. Marlin U. Thomas, the handbook was cited as "well designed and well developed" by Don H. Green, Executive Director of the Institute of Industrial Engineers. He further describes the book as an essential element in the critical role of enhancing our nation's security. Chapters were contributed by AFIT faculty members Dr. Jeffrey K. Cochran, Dr. James T. Moore, Dr. Raymond R. Hill, Dr. Richard F. Deckro, Dr. Daniel T. Holt, and AFIT Staff member, Mr. Richard Freeman. The handbook is available from CRC Press (http://www.crcpress.com).

First AFIT Distinguished Professor Award

Over twenty years of service and lasting contributions to the field of Aerospace Engineering have earned Dr. Shankar Mall the first AFIT Distinguished Professor award. The impact of his leadership has been significant in guiding the theses and dissertations of more than 150 masters, doctoral and post-doctoral students. He has published over 350 technical journal articles, and he has presented papers at more than one hundred national and internal technical meetings. Dr. Mall has been nationally recognized by the technical community, and honored as a Fellow of the American Society of Mechanical Engineers, and as an Associate Fellow of the American Institute of Aeronautics and Astronautics. He was the recipient of the 1997 Outstanding Engineer and Scientist Award from the Affiliated Societies Council of Dayton, Ohio. He served as head of the Department of Aeronautics and Astronautics at AFIT from 1990-1998 and has been recognized on eight occasions for outstanding teaching. The current Aeronautical and Astronautical Department Head, Dr. Bradley Liebst, cited Dr. Mall as "an inspiration in his role as professor and a mentor in his role as Department Head."

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AFIT Vision Statement

"World leader for defense technological education, research, and consultation."

Dr. Richard F. Deckro Named MORS Fellow

Dr. Richard F. Deckro, Professor of Operations Research, was elected a Fellow of the Military Operations Research Society (MORS)—one of the highest honors an academic can attain in a professional society. Election is a lifetime appointment. Only fifty-eight individuals have been named since the inception of the honor with two Fellows in 2009. In announcing this honor, the selection notification cited Dr. Deckro's continued outstanding and dedicated service to MORS, and the many projects he has conducted for MORS and the analysis community. Society members include a cross section of the best defense analysts, operators, and managers from government, industry, and academia. Dr. Deckro participates in society activities, often taking leading roles, including service as the Editor of Military Operations Research since 2001. He is also the Director of the Future Operations Investigation Laboratory at AFIT.

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FACULTY NOTES

American Physical Society Fellow

Dr. Robert L. Hengehold, Professor of Physics, has been named a fellow in the American Physical Society (APS) in 2009 for his "pioneering contributions to semiconductor material characterization, over 30 years of distinguished and dedicated leadership in the development of graduate applied physics programs for military officers, and services to the physics community through APS sectional meetings specifically on applied and industrial physics." The prestigious award is limited to no more than one-half of 1% of the APS membership.

Dr. Hengehold has been a member of the AFIT faculty for 40 years. He recently stepped down as the Department Head of the Engineering Physics department after holding that office for 25 years. Dr. Hengehold is the author of over 100 archival publications and over 200 presentations at technical meetings. He has served as advisor on 17 doctoral dissertations and 80 Master's thesis. He received the Air University Commander's Award for Faculty Achievement in 1982, the Gage H. Crocker Outstanding Professional Achievement Award from the Affiliate Society Council of the Engineering and Science Foundation of Dayton in 1997, and the General Bernard A. Schriever Award for 1999.

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New Faculty Profile—Dr. Julie Jackson

Dr. Julie Jackson joined AFIT as an Assistant Professor in the Department of Electrical Engineering in September. A graduate of The Ohio State University, Julie completed her PhD in Electrical Engineering in August 2009. Prior to joining AFIT, Julie was a Graduate Research Fellow at the Air Force Research Laboratory. She has received fellowship support from the Dayton Area Graduate Studies Institute, the National Science Foundation, and the Ohio Board of Regents.

What attracted you to AFIT?

"I like that AFIT is a small graduate school with an emphasis on high-quality research. My research interests in radar signal processing fit well in AFIT's role of supporting the Air Force, and AFIT is geographically located near the Air Force Research Laboratory providing ample opportunity for collaborative research. In addition, I was attracted to AFIT's reputation for expert faculty and highly motivated students."

What is your major field of research?

"I am a faculty member in the Radar Signals Processing track in the Department of Electrical and computer Engineering. My research interests include signal and image processing, electromagnetic and statistical Modeling, and data exploitation. I primarily work in developing algorithms for imaging sensors such as synthetic aperture radar."

What classes will you be teaching during 2010?

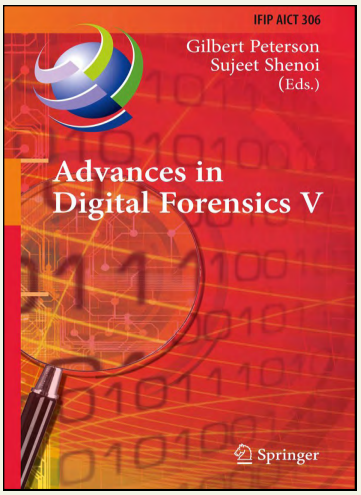
"I will be teaching EENG 665-Random Signal and Systems Analysis and EENG 680-Multidimensional Signal and Image Processing."

Air Force Meritorious Civilian Services Awards

Dr. Heidi R. Ries and Dr. Nathaniel Davis have each received the Meritorious Civilian Service Award for distinguished service to the Air Force. Dr. Ries joined AFIT in 1999 as the Associate Dean for Research, and has served as the Dean of Research since 2005. Prior to joining AFIT, she served as Director of the Center for Materials Research at Norfolk State University. Dr. Davis is the Head of the Department of Electrical and Computer Engineering; he joined AFIT in August 2005 after serving as the Assistant Head of the Department of Electrical Engineering at Virginia Polytechnic Institute and State University. Dr. Ries' award was presented by General Stephen R. Lorenz, Commander, Air Education and Training Command. AFIT has achieved an almost 400% increase in external sponsor support as a direct result of Dr. Ries' leadership and initiative. Dr. Davis was noted for his leadership in restructuring the Electrical and Computer Engineering department, revamping the master's and doctoral curriculum, and implementing more efficient budgeting procedures. His award was presented by Brigadier General Paula Thornhill.

Outstanding Engineer and Scientist Award

Dr. Adedeji Badiru, Professor and System Engineering Management Department Head, has received the Outstanding Engineer and Scientist Award from the Affiliate Societies Council of Dayton. The award is given for overall lifetime professional Accomplishments. Dr. Badiru was instrumental in creating The Systems Engineering curriculum at the University of Lagos in his native country of Nigeria, and he served as the Head of the Industrial Engineering Department at the University of Tennessee and Dean of University College at the University of Oklahoma before joining AFIT in 2006.



Advances in Digital Forensics V

Advances in Digital Forensics V: Fifth IFIP WG 11.9 International Conference on Digital Forensics, Orlando, Florida is now available. Co-edited by AFIT professor Gil Peterson and Sujeet Shenoi, the book was published by Springer-Verlag, New York and describes original research results and innovative applications in the discipline of digital forensics. In addition, the book explores major technical and legal issues related to digital evidence and crime investigation. It is available for purchase from major online book distributors and at: http://www.springer.com/computer/information+systems/book/978-3-642-04154-9

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STUDENT and ALUMNI HIGHLIGHTS

VOIP Research Wins Student Blue Dart Award

There is a good chance that the telephone in your office is actually a computer that happens to resemble a phone. Many organizations are moving towards integrating Voice over Internet Protocol (VoIP) phones into their communications infrastructure in order to lower costs by reusing existing network wiring and hardware. VoIP phones can offer savings and convenience but at the cost of potentially introducing risk into enterprise networks.

Researchers at the AFIT Center for Cyberspace Research in Electrical and Computer Engineering department are investigating network risks and performance degradation issues surrounding the use of VoIP phones. Captain Benjamin W. Ramsey recently completed research in which he demonstrated the ease by which someone could exploit VoIP phones to intercept and record ongoing conversations, spoof caller IDs, and completely disable a phone—even attack the underlying network infrastructure. He also quantified the impact on voice quality by securing wireless VoIP phone conversations using various forms of encryption. Results indicate that IEEE 802.11n can provide "fair" voice quality for up to 75 simultaneous VoIP calls secured with WPA2 (Wi-Fi Protected Access 2) or up to 40 calls secured with both WPA2 and transport mode IPsec (Internet Protocol Security). Both research efforts used off-the-shelf hardware easily found in typical office environments, as well as readily-available exploits found on the internet. Assistant Professor Barry E. Mullins directed these efforts. As a result of this research, Captain Ramsey won the Air Education and Training Command Top Student Blue Dart award for 2008-2009.

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Navigation Research Excellence Award

How do you track a vehicle when weather or other conditions make it impossible to follow visually? Using the earth's magnetic field and some small and inexpensive sensors, Captain Will Storm has devised a way to create "electronic bread crumbs" enabling one vehicle to trail another in adverse conditions. Knowing that the earth's magnetic field is fairly consistent he theorized that local magnetic field variations, which make magnetic compasses useless indoors, could actually be used to determine position.

His fundamental approach was to measure the three-dimensional magnetic field using a three-axis magnetometer. The device, slightly smaller than a computer mouse, provided the data to determine a position by comparing the magnetometer measurements to a map of the magnetic field. In a proof-of-concept demonstration, he was able to calculate a vehicle's position to well within one meter of accuracy. For his outstanding research, Capt Storms was presented with the "AFIT Navigation Research Excellence Award" by the Dayton Section of the Institute of Navigation.

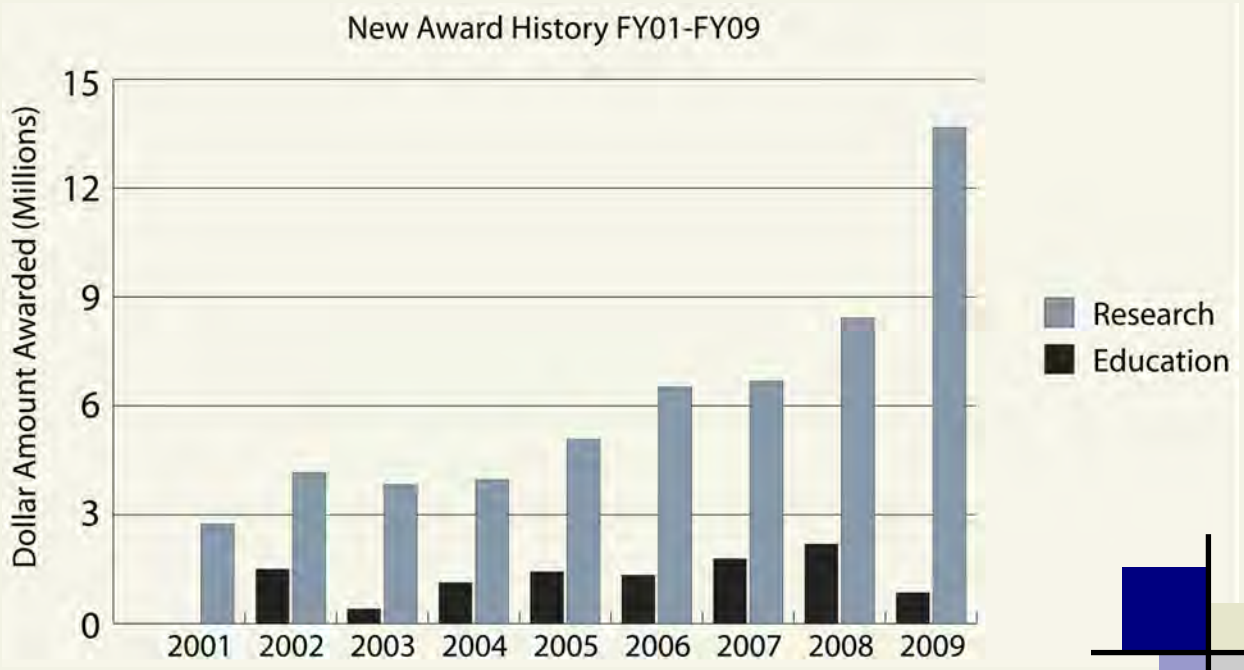
Outstanding Air Force Engineer Award

Captain Jason Paul, an AFIT Electrical Engineering PhD candidate, has won the Eglin Engineering and Technical Management Award for Mid-Career Military Engineering Excellence. Captain Paul was cited for his work in transitioning SOFTNet software for special operations teams, increasing situational awareness and targeting efficiency; effectively decreasing the kill chain by 70%. His inventive work in onboard computer processing for MicroAir Weapons has paid dividends allowing autonomous operation and increasing accuracy ten-fold while making the weapons resilient against radio frequency jamming.

New FY09 Awards to Academic Departments & Research Centers by Type

	Research		Education		Total	
Dept.	#	Dollars	#	Dollars	#	Dollars
Mathematics & Statistics (ENC)	6	216,792	-	-	6	216,792
Electrical & Computer Eng (ENG)	67	4,649,901	1	373,647	68	5,023,548
Engineering Physics (ENP)	35	4,042,037	8	364,991	43	4,407,028
Research & Sponsored Programs (ENR)	1	16,559	-	-	1	16,559
Operational Sciences (ENS)	20	2,363,794	1	20,000	21	2,383,794
Systems & Eng Management (ENV)	15	1,088,208	1	60,000	16	1,148,208
Aeronautical & Astronautical Eng (ENY)	40	1,290,492	1	26,958	41	1,317,450
TOTAL	**184**	**13,667,783**	**12**	**845,596**	**196**	**14,513,379**
Center*						
Advanced Navigation Technology Center (ANT)	14	789,965	-	-	14	789,965
Center for Directed Energy (CDE)	12	1,499,692	4	143,255	16	1,642,947
Center for Cyberspace Research (CCR)	15	2,341,321	1	373,647	16	2,714,968
Center for MASINT Studies and Research (CMSR)	10	1,575,288	-	-	10	1,575,288
Center for Operational Analysis (COA)	22	2,380,190	1	20,000	23	2,400,190
Center for Systems Engineering (CSE)	7	290,832	1	60,000	8	350,832
TOTAL	**80**	**8,877,288**	**7**	**596,902**	**87**	**9,474,190**

*All Center funds are also included in departmental funding

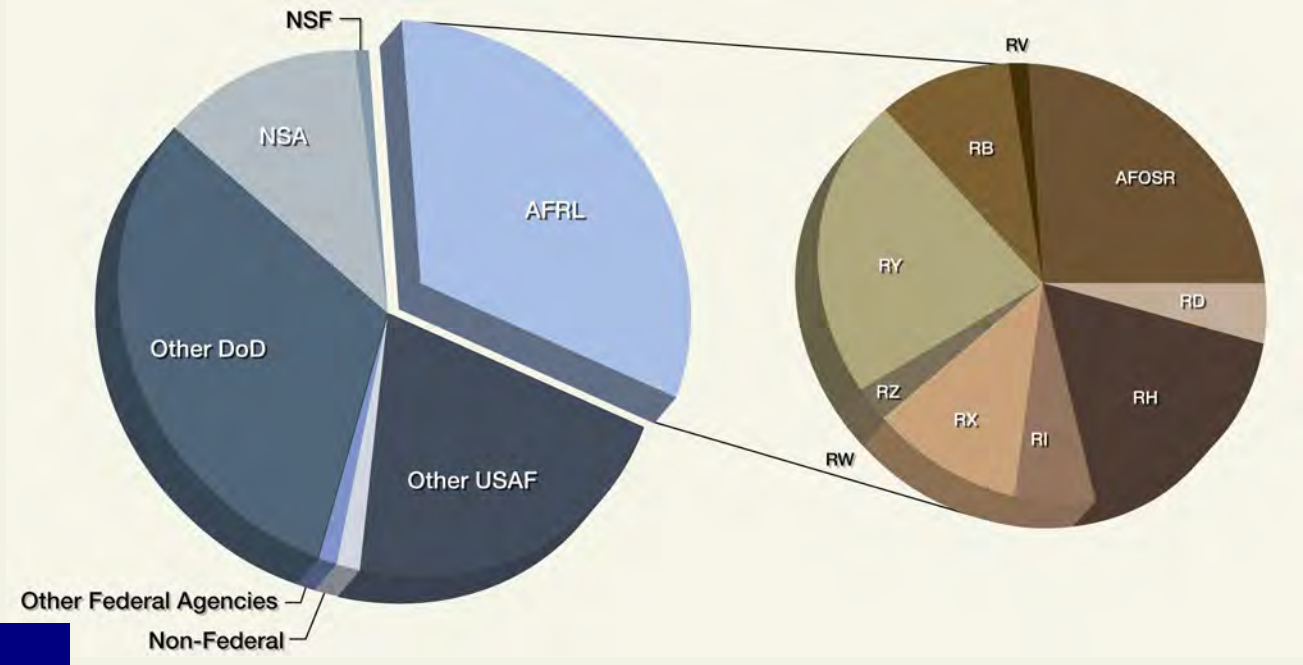


RESEARCH DATA

New FY09 Awards to Academic Departments & Research Centers by Sponsor

	AFRL	*Other USAF*	*Other DoD*	*NGA*	*NSF*	*NSA*	*Other Federal*	*Non-Federal*	*Total*
Dept.	***Dollars***	***Dollars***	***Dollars***	***Dollars***	***Dollars***	***Dollars***	***Dollars***	***Dollars***	***Dollars***
ENC	196,792	20,000	-	-	-	-	-	-	216,792
ENG	2,054,141	401,930	561,324	-	100,000	1,796,155	-	109,998	5,023,548
ENP	497,712	1,513,186	2,240,130	-		-	156,000	-	4,407,028
ENR	16,559	-	-	-	-	-	-	-	16,559
ENS	175,000	764,442	1,400,352	-	-	-	-	44,000	2,383,794
ENV	823,836	185,000	129,372	-	-	10,000	-	-	1,148,208
ENY	926,422	185,685	158,385	-	26,958	-	-	20,000	1,317,450
TOTAL	**4,690,462**	**3,070,243**	**4,489,563**	**-**	**126,958**	**1,806,155**	**156,000**	**173,998**	**14,513,379**
Center*									
ANT	350,000	209,930	130,035	-	-	-	-	100,000	789,965
CCR	791,813	17,000	-	-	100,000	1,806,155	-	-	2,714,968
CDE	358,922	-	1,284,025	-	-	-	-	-	1,642,947
CMSR	-	1,213,186	362,102	-	-	-	-	-	1,575,288
COA	207,200	584,442	1,564,548	-	-	-	-	44,000	2,400,190
CSE	49,500	185,000	96,332	-	-	-	-	20,000	350,832
TOTAL	**1,757,435**	**2,209,558**	**3,437,042**	**-**	**100,000**	**1,806,155**	**-**	**164,000**	**9,474,190**

*All Center funds are also included in departmental funding



Sponsors of FY09 Projects

Selected Large Awards FY09

$2.1 Million Award for Civilian Student Scholarships

The Center for Cyberspace Research has been awarded a $2.1 million grant from the National Science Foundation to continue its successful Scholarship for Service fellowship program. To date, 15 students have received full scholarships through the program, earning Master's degrees in Cyber Operations. Upon degree completion, the students are obligated to two years of civilian service at a federal, state, or local government agency. Twenty-four fellowships are expected to be awarded during the 2009-2012 renewal grant period. Interested individuals can link to http://www.afit.edu/CCR/CyberCorp/ for application information.

Individuals seeking financial assistance for other AFIT programs have a number of options including assistantships, fellowships, internships, and scholarships. Link to http://www.afit.edu/en/admissions/officeinfo.cfm?a=tuition for more information.

Tactical SIGINT Technology Program
$1,338,000 - National Security Agency
Principal Investigator: Dr. Rusty Baldwin

AFIT Analysis Support to Joint Improvised Explosive Device Defeat Organization* (JIEDDO) *Task 1a –Support JIEDDO Initiative Assessment Plans
$587,560 - JIEDDO
Principal Investigator: Dr. Jeffery D. Weir

FY09 High Energy Laser Joint Technology Office Modeling & Simulation Tactical Area Working Group Product Development
$425,000 - High Energy Laser Joint Technology Office
Principal Investigator: Dr. Salvatore J. Cusumano

Information Assurance Scholarship Program Tuition and Resource Support for the AFIT Center for Cyberspace Research
$373,647- National Security Agency
Principal Investigator: Dr. Richard A. Raines

High Power Diode Pumped Alkali Vapor Lasers and Analog Systems
$352,450 - High Energy Laser Joint Technology Office
Principal Investigator: Dr. Glen P. Perram

Chief Technology Officer (Center for MASINT Studies and Research)
$328,745 - Secretary of the Air Force
Principal Investigator: Dr. Ronald F. Tuttle

Joint Distribution Process Analysis Center and AFIT Distribution Research Proposal
$300,000 - USTRANSCOM
Principal Investigator: Dr. James T. Moore

ONIR (Overhead Non-Imaging Infrared) Ground Truth Support
$289,441 - National Air & Space Intelligence Center
Principal Investigator: David Bunker

Analysis of Thermal Flash Effects on Surfaces for Post-Event Nuclear Forensics
$266,300 – Defense Threat Reduction Agency
Principal Investigator: James C. Petrosky

AFIT Analysis Support to Joint Improvised Explosive Device* Defeat Organization (JIEDDO) *Task 2ba –Analyze Enemy Social Network Interactions
$249,260 - JIEDDO
Principal Investigator: Dr. Richard F. Deckro

Project Lake Effect - Phase 1
$230,000 - National Air & Space Intelligence Center
Principal Investigator: Dr. Ronald F. Tuttle

CyberCraft Environment Modeling for C3
$221,130 - Air Force Research Laboratory (AFRL/RI)
Principal Investigator: Dr. Gilbert Peterson

Foundation Research for the Development of a Cyber Incident Mission Impact Assessment (CIMIA) Process
$210,000 - Air Force Research Laboratory (AFRL/RH)
Principal Investigator: Dr. Michael R. Grimaila

CENTERS AT AFIT

Center for Operational Analysis
http://www.afit.edu/en/coa/
Lt Col Stephen Chambal

Center for Directed Energy
http://www.afit.edu/en/de/
Dr. Salvatore Cusumano

Advanced Navigation Center
http://www.afit.edu/en/ant
Dr. John F. Raquet

Air Force Center for Systems Engineering
http://www.afit.edu/cse/
Colonel John Paschall, Acting

Center for Measurement and Signature Intelligence
http://www.afit.edu/en/cmsr/
Dr. Ronald F. Tuttle

Center for Cyberspace Research
http://www.afit.edu/en/ccr/
Dr. Richard Raines

AFIT AT A GLANCE

Current Enrollment

Master's: 597
Doctoral: 122
Certificate: 64
Other: 14

Enrollment by Branch of Service

Air Force Officer: 524
Air Force Enlisted: 15
International: 31
Sister Service: 47
Civilian/Other: 180

Alumni

Total: 18,000+

Scholarly Activity for 2009

Books: 5
Book Chapters: 30
Journal Articles: 168
Proposals Submitted: 214

Personnel

Faculty: 139
Support Staff: 131

Land and Buildings

Acreage: 12
Gross Square footage: 500,000 sq ft
Buildings: 9

AFIT Directory

For specific information regarding faculty research areas, please see the AFIT Directory at http://www.afit.edu/directory/Expertlist.cfm

Sponsoring Thesis Topics

AFIT encourages input from your agency that aligns our research and student education to relevant areas to ensure the technological superiority and management expertise of the U.S. Air Force and the Department of Defense. Each topic submitted has a strong positive impact on AFIT's ability to focus on research relevant to real-world requirements. http://www.afit.edu/

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